To: Controlled Ground Water Area Petition File No. 41I-S116636

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Date: August 5, 2006

Subject: Review of North Hills Controlled Ground Water Area study

Summary

The North Hills Controlled Ground Water Area was designated in October 2002 in response to concerns over ground-water availability and high nitrate concentrations in ground water. During the temporary control period, ground water levels, water quality, and flow were monitored and monitoring data and characteristics of aquifers within the North Hills were evaluated by the Montana Bureau of Mines and Geology (MBMG). The purpose of this review is to summarize monitoring and development completed during the control period and to comment on an open-file report prepared by MBMG.

MBMG delineated three separate but interconnected aquifers in the North Hills consisting of pre-Tertiary bedrock, poorly consolidated Tertiary sediments, and Quaternary alluvium. Their discussion of the character of aquifers and the importance of local occurrence of water producing fractures or gravel lenses serve as a useful guide for land owners to judge the prospects of obtaining water in the North Hills.

MBMG calculated a water budget to quantify the relationship between recharge and discharge from the aquifer including withdrawal from wells. They conclude from this water budget that withdrawal from wells accounts for about four percent of the total water budget for the North Hills temporary control area. Further, MBMG observes that water levels in wells in the southern part of the temporary control area have a seasonal pattern correlated to recharge during the irrigation season that is generally opposite the pattern of water level fluctuations in more northerly wells that are not affected by irrigation. Leakage from the Helena Valley Irrigation Canal and Silver Creek plus infiltration of excess irrigation water and precipitation recharge and determine water levels in the southern part of the control area. Infiltration of snowmelt and rainfall are the primary sources of recharge north of the canal that influences ground water levels. The extent that withdrawals from wells affect water levels is uncertain. Climate scale fluctuations of precipitation and streamflow can explain water level declines in 11N04W24 that resulted in well problems and brought about designation of the control area. In contrast,

withdrawals from wells may partially explain water level declines that have caused several wells to be replaced in 11N03W06.

The primary drinking water standard for nitrate of 10 mg/l was exceeded in water samples from two wells in the North Hills during the temporary control period. Another eleven wells had nitrate levels between 5 and 10 mg/l. Nitrate in these wells are derived from local sources of human or animal waste, organic nitrogen from soil, or fertilizer. Nitrate concentrations in the remaining 114 wells samples were less than 5 mg/l.

The distribution of recharge and the connection of aquifers in the North Hills to the Helena Valley Aquifer are important considerations when making conclusions about water availability and the potential for new wells to interfere with existing wells. Specifically, recharge is concentrated in the southern 20 percent or less of the control area; an area that also is closely connected to the Helena Valley Aquifer. The influence of pumping on water levels in areas with relatively much less recharge than the southern 20 percent of the control area is uncertain.

Introduction

The North Hills Controlled Ground Water Area was designated on October 11, 2002 pursuant to petition 41I-S116636 in response to concerns over problems with wells and nitrate concentrations in ground water. The purpose of the temporary designation was to gather information on aquifer conditions and to determine if withdrawals from wells exceed recharge, if new wells will interfere with other wells, and if nitrate contamination that may be affected by withdrawals is developing. The Lewis and Clark County Local Water Quality Protection District (LCCWQPD) and Montana Bureau of Mines and Geology (MBMG) obtained a grant through the state Renewable Resource Grand and Loan Program to collect data and evaluate water availability and quality problems alleged in the petition. Water level data were collected by LCCWQPD, MBMG and the Montana Department of Natural Resources and Conservation (DNRC). LCCWQPD, MBMG, and owners of new wells collected and analyzed water samples for nitrate and in some samples chloride, or coliform bacteria. Well drillers collected samples of drill cuttings for selected wells to be split and catalogued by DNRC. MBMG compiled and analyzed these data and described the hydrogeology in an open-file report available from the DNRC webpage.

Table 1 at the end of this report lists the number of permits issued or pending for wells within the North Hills temporary CGWA during the control period. Permits for 235 individual wells (< 35 gpm and 10 ac-ft) and public water supplies for 220 residences, 24 commercial lots, and one gravel pit were issued during the control period. In addition, applications for permits for public water supplies for an additional 348 residences and 4 commercial lots are pending. Of the individual wells permitted during the control period, 100 were drilled in either Rosemary Acres subdivision in the southwest corner of Township 11 North, Range 04 West, Section 24 (11N04W24) or Gable Estates subdivision in 11N03W13 and 11N03W14. Another 44 wells were drilled in 11N03W06 or 11N03W07.

Over 30 reports of well problems during 2000 and 2001, mostly in the northwest corner of 11N04W24, led in large part to designation of the North Hills temporary CGWA. The problems reported to LCCWQPD included milky or sandy water, reduced pressure or production, and air in pipes. Some water users were able to lower their pumps to alleviate problems, but approximately 15 wells had to be replaced or deepened (Table 2). In addition, another 20 wells required replacement during the term of the temporary CGWA. Many of those wells are located in the Cedar Hills and Prairie View Acres subdivisions located in the southeast corner of 11N03W06.

Review and Comments on MBMG Open File Report

The open-file report entitled *Hydrogeology of the North Hills, Helena, Montana*, August 2006, prepared by MBMG includes a discussion of the general geography and geology of the control area and interpretations of the geologic framework and aquifer geometry, water budget, causes of water level changes, and concentrations of nitrate in ground water.

Geologic Framework and Aquifer Geometry

MBMG delineated three separate but interconnected aquifers in the North Hills consisting of pre-Tertiary bedrock, poorly consolidated Tertiary sediments, and Quaternary alluvium. From their discussion, water availability in pre-Tertiary bedrock is dependent on whether a well intersects productive fractures. Similarly, whether a well in Tertiary sediments intercepts a sand or gravel lens in otherwise fine grained sediments determines water availability. In contrast, Quaternary alluvium contains more significant thicknesses of sand and gravel and yields more productive wells.

Water Budget

MBMG calculated a ground-water budget to estimate recharge to and discharge from the aquifer system in the North Hills. Recharge components of this budget include infiltration of precipitation and excess irrigation water, and losses from Silver Creek and the Helena Valley Irrigation Canal and associated lateral ditches. Estimates of canal and ditch leakage as well as infiltration of excess precipitation and irrigation water are derived from work by Briar and Madison (1992). Because there is not a stream gage on Silver Creek, infiltration from Silver Creek is derived by estimating mean streamflow from data for Tenmile Creek. Discharge components of the MBMG water budget include outflows through agricultural drains and withdrawals by wells. Outflow from drains was measured and withdrawal from wells was estimated from actual metering of two of the larger subdivisions in the control area. The water budget also includes estimates of ground-water underflow into the area from the north and out of the area to the south that were calculated using Darcy's Law with estimates of hydraulic gradient and aquifer transmissivity.

The overall approach and assumptions MBMG made in calculating the water budget for the control area are reasonable, however component estimates are uncertain to varying degrees. Estimates of ground water fluxes into and out of the control area are most uncertain because these values are proportional to transmissivity, an aquifer property that varies considerably with location and direction, and has been measured in only a few locations. In addition, the possible role of east-west trending faults as impediments to ground-water flow from north to south adds additional uncertainty. Estimates of infiltration of excess irrigation water and precipitation are more certain than estimates of flux, although infiltration does vary because of irrigation practices, soil properties including moisture conditions and crop consumption. Canal and ditch leakage is difficult to measure accurately, however averages estimated for large reaches or numerous laterals are more accurate. Estimates of irrigation outflows and well withdrawals are based on measurements and, therefore probably are more reliable than other components of the water budget. For well withdrawals, the estimated rate of 0.5 acre-feet per year per residence MBMG used is considerably less than the 1.63 acre-feet that DNRC allows for domestic use and irrigation of ¼ acre or the average permitted annual volume of 2.5 acre-feet for the 235 individual wells drilled during the control period. The fact that residents in Skyview and Townview Estates, the two subdivisions MBMG chose to estimate average usage from, pay for water according to their use no doubt imposes a degree of conservation, resulting in less use than in subdivisions that do not meter usage. For example, Ranchview Estates is another large subdivision in the control area that does not meter individual usage. Lawns and landscaping are noticeably greener in Ranchview Estates and likely has a much higher average use rate. Conversely, irrigation at many residences outside large subdivisions is limited. Therefore, on the whole, the estimate of average withdrawal from wells probably is representative.

Ground-Water Levels

MBMG observes that water levels in wells in the southern part of the control area have a seasonal pattern correlated to the irrigation season. In these wells, leakage from the Helena Valley Irrigation Canal and its laterals, and infiltration of excess irrigation water cause water levels to rise sharply at the beginning of the irrigation season while an equally sharp recession starts when irrigation water is shut off in the fall. This water level pattern confirms that canal leakage and irrigation returns are important sources of recharge in these areas. MBMG also observes that water levels in wells that are not affected by irrigation or stream leakage decline through the spring and summer and rise through the fall and winter, generally opposite from the response in wells influenced by irrigation. This pattern of fluctuation occurs in the most heavily developed area in 11N03W07, but also in less developed areas. MBMG states that this response could be caused by pumping, but concludes that the water level pattern in these wells probably is related to recharge by snow melt and rainfall. On the other hand, several wells in a small subdivision in 11N03W06, immediately north of the most developed area have been replaced because of lower ground water levels. For this reason, well withdrawals cannot be ruled out as a partial cause of low ground-water levels during the summer in the vicinity of the heavily developed area in 11N03W07.

MBMG compares ground-water levels to the cumulative precipitation index to show that unusually low flow in Silver Creek during 2000 and 2001and resulting low ground water recharge can explain water level declines that caused numerous well problems reported in 11N04W24. They recommend that new wells should be drilled deeper in areas that rely on recharge from Silver Creek in anticipation of low flows in the future. Replacement well information in Table 1 shows that existing water users have been able to obtain adequate water at greater depths and indicates the MBMG recommendation may make sense. However, there are areas such as the southwest corner of 11N04W24 where alluvium is underlain by granite bedrock and availability of water at greater depth is less certain. It may not be feasible to drill deeper wells in areas like this to allow for fluctuations in recharge from Silver Creek.

Nitrate Concentrations

MBMG compared nitrate concentrations in 127 wells to the primary drinking water standard for nitrate in public water supply wells and discuss the probable sources of high concentrations. The maximum contaminant level for nitrate of 10 mg/l established by EPA (1996) was exceeded in water samples from two wells in the North Hills during the temporary control period. Another eleven wells had nitrate levels between 5 and 10 mg/l. Nitrate concentrations in samples from the remaining 114 wells were less than 5 mg/l. MBMG conclude that Nitrate in these wells appears to be derived from human and animal waste, organic nitrogen from soil, fertilizer, or natural sources. The dispersed nature of the high values indicates the sources of nitrate are local and a large plume of contamination that could be spread by withdrawals from wells is not apparent.

Discussion

The MBMG report addresses the central issues that led to DNRC designating the North Hills CGWA. They delineated three interconnected aquifers within the control area and described the water producing characteristics of each. MBMG identified sources of recharge in the control area and calculated a water budget that relates withdrawals from wells to recharge. The exact quantities of the components of the water budget are uncertain, but estimates of the relative magnitudes of recharge and withdrawals from wells are supported by measurements and reasonable assumptions. Further, the data provided can be used to evaluate whether new wells will interfere with other wells and whether there is a plume of nitrate contamination in the control area that can migrate in response to new withdrawals.

There are additional factors that should be considered when making conclusions based on the results of the North Hills study. Properties of the aquifers identified by MBMG are spatially variable and result in a wide range of well yields. The occurrence of low productivity wells is an indication of the absence of productive fractures or gravel layers at a specific location and is not typically an indication of over use or the potential for future over use. In contrast, greater potential for over draft exists in areas where high production wells are possible. The distribution of recharge, and the connection of aquifers in the North Hills to the Helena Valley Aquifer are important considerations when making conclusions from the water budget calculated by MBMG. Much of the recharge from irrigation and canal and stream losses occurs in the southern 20 percent or less of the control area. Much of the newly permitted and pending uses are in this same area; however a considerable amount of the current use is in an area (11N03W07) with relatively low recharge. In addition, the Quaternary alluvium and possibly parts of the Tertiary sediments in the southern part of the control area are in close hydraulic connection to the Helena Valley Aquifer. The significance of this connection is evident in ground water level monitoring and aquifer testing data from several proposed public water supply wells located near the Helena Valley Canal in 11N03W17 and 11N03W18. Ground water levels in these high-yield wells completed between 200 and 300 feet deep rise and fall in coincidence with operation of the canal and the irrigation season, indicating a close connection between the wells and recharge from canal and ditch leakage and return flows. However, shallow wells do not respond during aquifer tests of these production wells, most likely because the aquifer tapped by the high-yield wells is locally confined by overlying fine-grained strata. The most likely interpretation of the pattern of water level fluctuations in these wells is that the fine-grained confining strata are not continuous across the Helena Valley and the seasonal rise and fall of water levels in these wells corresponds to the seasonal rise and fall of the Helena Valley Aquifer which responds to canal operation and irrigation across the entire valley. Under this interpretation, a water budget for the entire Helena Valley Aquifer is a more important measure of water availability in the southern part of the control area than a water budget for the North Hills temporary CGWA.

Recognition of the connection between aquifers in the North Hills and the Helena Valley Aquifer also is important when considering the question of the potential effects of new wells on existing wells. Use of a new well in the southern portion of the control area that is hydraulically connected to the Helena Valley Aquifer will reduce water levels creating a cone of depression that expands into the Helena Valley Aquifer. Assuming confining layers are discontinuous, the cone of depression will impinge on hydraulically connected surface waters including Lake Helena and the lower reaches of Tenmile Creek and Silver Creek. Capture of water that otherwise would discharge to these surface waters or be consumed by phreatophyte vegatation as a result of reduced ground water levels ultimately will offset the new usage. The magnitude of drawdown at other wells that occurs before capture balances the new use depends on the properties and geometry of the aquifer and the distance to the surface waters, but is at best partially dependent on the water budget within the control area (Theis, 1938; 1940). The result is that an amount much greater than local recharge in the North Hills can be captured because of the connection between the wells, the Helena Valley Aquifer, and Lake Helena and/or its tributaries.

The full cause of water level fluctuations in the vicinity of subdivisions in 11N03W07 is uncertain. I agree that water levels in these wells probably rise at least in part in response to recharge from snowmelt and early spring rains. This pattern of seasonal fluctuations also could result from seasonal affects of pumping followed by near-full water level recovery as stored ground water redistributes in fall and winter. Because the period of low recharge is the same as the period of peak use, the data are not sufficient to separate the effects of recharge and usage on water levels. Further, MBMG uses a long-term water level record from a well in a relatively undeveloped area (11N03W11BBBA) to conclude there is a long-term water level decline related to climate. Water level declines that have resulted in a large number of replacement wells in the area of the Cedar Hills subdivision in 11N03W06 could be a result of this climate effect or the effects of pumping in adjacent subdivisions in 11N03W07.

References

Theis, C.V., 1938. The significance and nature of the cone of depression in ground-water bodies, Economic Geology, pp. 889-902.

Theis, C.V., 1940. The source of water derived from wells: essential factors controlling the response of an aquifer to development, Civil Engineering, V. 10, p. 277-280.

U.S. Environmental Protection Agency, 1996, Drinking water regulations and health advisories: Washington, D.C., Office of Water, EPA 822-R-96-001, 11p.

Table 1. Number and volume in acre-feet per year for permitted and pending new uses since October 2002 (data from DNRC water rights database).

Tsp Rge Section	< 35 gpm and 10 ac-ft		> 35 gpm or 10 ac-ft	
	# Permits	Volume	# Permits	Volume
T11N R03W 01	1	1.0	0	0.0
T11N R03W 02	2	3.8	0	0.0
T11N R03W 03	2	3.3	0	0.0
T11N R03W 04	2	3.9	0	0.0
T11N R03W 06	24	62.9	0	0.0
T11N R03W 07	20	53.7	1	256.0
T11N R03W 08	2	6.6	0	0.0
T11N R03W 09	3	6.2	0	0.0
T11N R03W 10	5	26.1	0	0.0
T11N R03W 11	2	3.3	0	0.0
T11N R03W 12	1	2.3	0	0.0
T11N R03W 13	21	67.5	0	0.0
T11N R03W 14	17	40.1	0	0.0
T11N R03W 15	2	3.9	0	0.0
T11N R03W 16	2	2.3	0	0.0
T11N R03W 17	3	13.1	3	747.0
T11N R03W 18	10	24.4	1	41.3
T11N R03W 19	2	6.1	0	0.0
T11N R04W 01	8	24.9	0	0.0
T11N R04W 02	10	29.2	0	0.0
T11N R04W 03	2	5.3	0	0.0
T11N R04W 09	3	4.9	0	0.0
T11N R04W 10	3	4.3	0	0.0
T11N R04W 11	3	9.6	0	0.0
T11N R04W 12	4	8.4	0	0.0
T11N R04W 13	6	17.3	1	48.9
T11N R04W 14	5	11.8	0	0.0
T11N R04W 15	1	0.6	0	0.0
T11N R04W 22	2	3.3	0	0.0
T11N R04W 23	1	1.6	0	0.0
T11N R04W 24	61	118.7	0	0.0
T12N R03W 31	4	13.6	0	0.0
T12N R04W 34	1	5.0	0	0.0
Sum	235	589	6	1093.2

Table 2. Replacement wells within the North Hills controlled ground water area (data from LCCWQPD, DNRC water rights database, and MBMG Ground-Water Information Center).

New Well				Old Well				Location
Year	Depth	SWL	Yield	Year	Depth	SWL	Yield	Twp Rge Sec Tract
1996	460	125	8		230			T11NR04W13BDBB
1996	140	75	20	1979	95	57	12	T11NR04W01CB
1999	215	109	35	1975	150	98	35	T11NR04W13AAAD
2000	141	91	25	1993	100	88	25	T11NR04W06ABD
2000	228	112	25		139			T11NR03W06DC
2000	330	66	100	1992	121	23	15	T11NR04W23AAC
2001	180	87	15	1981	120	80	20	T11NR04W24BBA
2001	100	100	30		30		15	T11NR04W24ADD
2001	200			1982	120	80	20	T11NR04W03CB
2001	280	90	8	1976	97	70	15	T11NR04W13CCB
2001	160	90	25					T11NR04W24A
2001	200	85	35					T11NR04W24BBB
2001	155	93	35	1964	95	78	10	T11NR04W24ABD
2001	155	95	30	1973	103	83	18	T11NR04W24ABC
2001	180	87	15	1981	120	80	20	T11NR04W24BBA
2001	200			1989	112	40	20	T11NR04W24BBB
2002	200	120	30	1977	133	85	20	T11NR03W18BBC
2002	220	120	20	1978	100	78	16	T11NR03W18BBD
2003	170	85	40	1991	105	75	15	T11NR04W02AAD
2003	200	50	25	1975	98	30	12	T11NR04W12BCD
2003	200	124	50	1984	135	90	15	T11NR03W06DCA
2003	175	90	50	1984	88	72	30	T11NR03W05CBB
2003	535	50	20	1977	220	70	12	T11NR03W08DCB
2003	400	173	5	1997	220	130	5	T11NR04W12CCBD
2003	209	103	60	1978	114	90	18	T11NR03W06DBDD
2003	91	26	20	1973	62	40	20	T11NR03W18DAA
2003	220	114	30	1995	119	44	15	T11NR03W06DBB
2003	170	85	40	1977	95	45	15	T11NR04W02AADD
2004	280	20	60	1984	110	15	10	T11NR03W14CBB
2004	178	98	20	1978	140	85	8	T11NT03W06DCC
2004	210	117	60	1977	130	80	20	T11NR03W06DCA
2004	125	74	50	1975	77	64	20	T11NR04W01CCDB
2004	480	140	18	1979	160	110	9	T11NR04W02DCC
2004	304	143	20	1976	153	103	8	T11NR04W02CDD
2004	159	107	25					T11NR03W18BBBC
2004	150	90	20	1979	90	64	15	T11NR03W06DAD
2004	120	38	30	1978	57	30	10	T11NR03W08DDB
2004	200	111	10		130			T11NR03W06DCC